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"Ray-Pasteurizing of Produce Will Come First"

So says QM food-radiation expert after special trials prove need of "threshold tactics" to guard against detrimental effects . . . Specific dosage tests revealed on numerous fruits and vegetables

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"Ray-Pasteurizing of Produce Will

So says QM food-radiation expert after special trials prove need of "threshold tactics" to guard against detrimental effects . . . Specific dosage tests revealed on numerous fruits and vegetables

PRIMARY PURPOSE of irradiating fresh fruits and vegetables is to reduce their surface microbiological flora, thereby cutting down post-harvest disease and increasing storage life.

Here, the foods' original values can be maintained by utilizing low-level irradiation as an adjunct to controlled temperatures and humidities. However, the dosage must be below a "threshold level" (above which detrimental texture, color, and appearance changes occur).

In many tests, which have included numerous samples inoculated with a wide variety of typical spoilage microorganisms, it has been noted that dosages needed for complete kill of plant pathogens run well above the threshold.

• **It appears, then, that optimum radiation control lies in pasteurizing the produce, rather than sterilizing it. And the first commercial food irradiation likely will be use of low dosages to extend refrigerated shelf-life.**

Safe and effective dosages lengthen holding periods either by partially inactivating the infecting organisms, or by extending the latent period of infection. The dose received, temperature of storage, and age of infection bear a direct relation to length of holding time without incidence of infection or visible radiation injury.

Fruits and vegetables evidence ray-sensitivity by softening and other texture aberrations. For such products as canning peas, asparagus, and pie apples, where a tenderizing effect is desirable, this effect is thought advantageous.

An increase in ripening has been noted as a maturation effect in peaches as a result of radiation. In green or pink tomatoes, however, one laboratory observed a pronounced delay in maturation.

Low level doses can significantly extend refrigerated shelf-life of blanched vegetables. It's conceivable that blanched vegetables, properly packaged and kept at refrigeration temperatures, could be retailed much as are frozen vegetables.

Significant findings resulted from studies to determine effects of product characteristics, irradiation conditions, and pre- and post-irradiation handling on radiation-pasteurized produce. Sealed cans bulged with gas after standing for several days. However, there was less gas in cans of irradiated foods than in cans containing the unirradiated controls.

Both variety and culture appear important from the standpoint of irradiation sensitivity, as was shown in irradiation of strawberries. A California varietal type grown in Utah showed greater resistance to tissue breakdown than the same berries grown in California. Marked varietal differences also were reported in potato-sprout inhibition.

Attempts have been made to reduce the necessary dose by pre- and post-radiation treatment with chemicals known to be inhibitory to microorganisms. In many cases this has resulted in objectionable sensory characteristics, without inhibition of microbiological growth.

It has been found that produce packaged in porous or perforated materials (rather than in hermetically sealed containers) can be maintained at a higher quality and over a longer period of time. The same held true for the irradiated produce.

Asparagus, tomatoes, snap beans, and strawberries that were irradiated while being flushed with air were preferred to the control samples in sealed cans.

Specifics on Fruits

Bananas: Irradiation of whole bananas reduces the rate of internal softening and accelerates skin blackening. A dose of 14,000 rads increased the shelf-life—the irradiated fruit being firm and satisfactory after 30 days' storage, while the control had softened completely. Ripening of hard green bananas is appreciably delayed by 37,000 rads.

Berries: Black currants given 93,000 rads definitely softened. At 186,000 rads a bleaching was noted. And at 930,000 there was definite loss of the typical sharp flavor. Irradiation in the frozen state partially protected the flavor.

Red currents and raspberries softened under 93,000 rads. Bleaching and a loss of sour flavor occurred at approximately 460,000 rads. With frozen berries, irradiation markedly protected color. However, texture quality decreased.

Berries taking over 460,000 rads were of unsatisfactory flavor. But the unpleasant flavor was averted by soaking the fruit in a 0.1% solution of potassium metabisulfite and draining before radiation. This treatment did not, however, protect color, texture, or natural flavor.

Combination of gamma rays (186,000 rads) and refrigeration notably prolonged storage life of naturally infected strawberries by delaying rot. Higher dosages (e. g., 465,000 rads) caused marked softening and bleaching. The refrigerated shelf-life of unirradiated strawberries was 62 days, whereas those irradiated at 1.4 megarads kept for 128 days—more than double.

As many as 93,000 rads can be given cranberries without tissue injury. But this dose doesn't appear to prevent further development of rot-inducing organisms that attack cranberries in storage.

With gooseberries, softening was evidenced at 93,000 rads and loss of typical flavor at 465,000. At 930,000 rads, irradiation flavor was produced, and bleaching occurred at 3.72 megarads. Flavor of gooseberries was notably aided by soaking in 50% sucrose after blanching.

Refrigerated shelf-life of blueberries given 140,000 rads was 162 days, against 70 days for the unirradiated controls. Spoilage of berries was probably autolytic. Irradiation and storage caused reddening of the berry flesh. Further, the vitamin-C content was significantly reduced.

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Come First"

Citrus fruits: Although storage life has been notably prolonged, 93,000 to 186,000 rads are not generally sufficient to kill all surface flora of whole fresh lemons and oranges.

Where such fruit was under severe penicillin-infection conditions, 140,000 rads were found optimum for shelf-life extension at incubation temperatures of 70-75F. without radiation-induced physiological breakdown.

Lemons could be held 11 days without adverse effects, whereas under cold storage this period was extended to a minimum of 14 days for this fruit, and over 33 days for oranges. Development of ray-induced brown injury and textural changes was more successfully controlled by low-temperature storage for oranges than for lemons.

Important flora after irradiation are the *Alternaria citri* ("black rot"). The fruit becomes more susceptible, apparently due to rind breakdown and textural change caused by gamma rays. At higher doses, lemons particularly become soft and discolored. Internal injuries (watery texture and hesperidin crystals) were found in the pulp of Florida Valencia oranges that took 900,000 rads (but not those receiving 450,000 rads).

With grapefruit, no appreciable loss of acceptability characteristics occurred under doses as high as 465,000 rads.

Grapes: Application of 465,000 rads appeared to control *Botrytis cinerea* (inoculation) in Tokay grapes without much adverse effect on the fruit. At 465,000 and 930,000 rads, no rot was noted 10 days after inoculation. Rot, however, was evident in the controls in 4 days. The only sensory changes evident were a fermentation odor and flavor at the 930,000 dose.

Apples: With three varieties of apples, 50,000 rads were highly effective in extending refrigerated life. Samples inoculated with *Penicillium expansum* required 93,000 rads for significant reduction of rot. And it took 186,000 to check rot in fruit held at 70 to 75F.

Dosages of 279,000 to 930,000 rads caused visible damage to the apples—as internal core breakdown, browning of skin, and texture softening. The control apples had rotted completely after 10 days of storage, whereas all rayed apples (doses as noted) were unrotted.

Irradiated apples slices deteriorated in flavor, color, and texture during storage. Slices irradiated to 930,000 rads were less preferred than those given 465,000. And slices from rayed mature apples were judged better than those from the immature.

Apple juice exposed to 930,000 rads had excellent flavor. But marked bleaching was noted at doses as low as 279,000.

Pears: Under higher-level doses (up to 744,000 rads) Bartletts suffered immediately in appearance, color, and odor (amount dependent on dose). At up to 200,000 rads, however, rayed mature Bartletts were similar in sensory characteristics to unirradiated pears. Green Bartletts, after taking up to 300,000 rads, showed good quality after 7 days incubation at 70F.

Stone Fruits: Apricots irradiated to 300,000 and to 500,000 rads at 100F. showed some shriveling, but were considered to be in good condition after 45 days' storage at 40F. The non-rayed controls and those given but 100,000 rads were shriveled and infested with mycelium (bread-mold type of fungus growth).

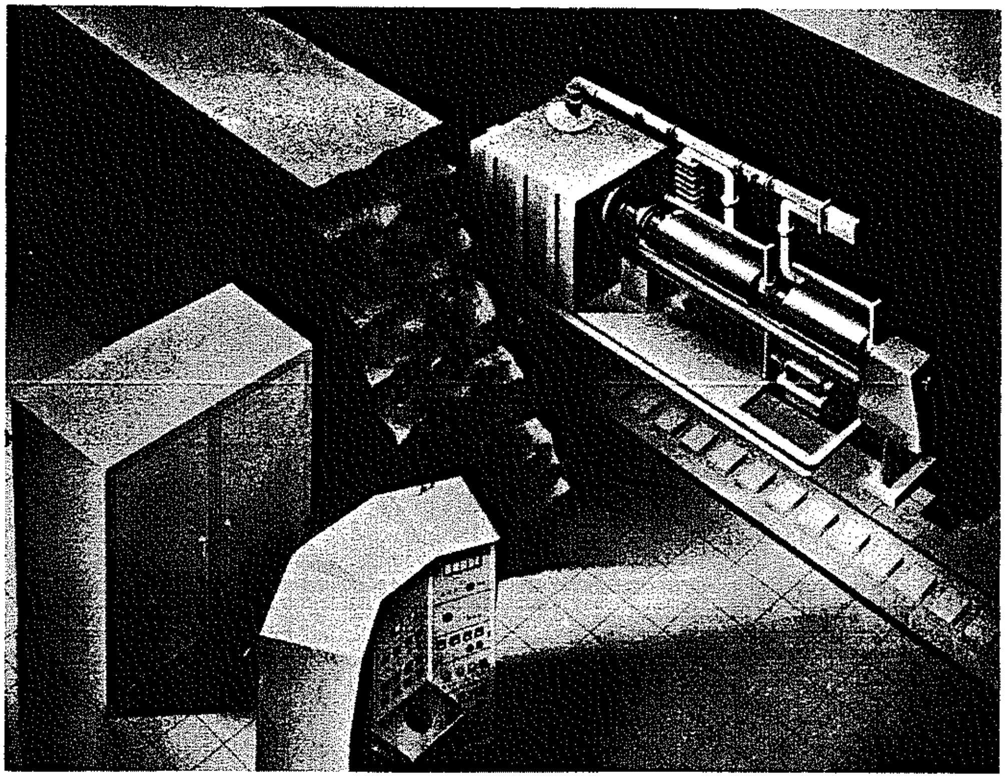
Little change was seen in acceptability characteristics of cherries given doses up to 3.72 megarads. The refrigerated shelf-life of unrayed sour cherries was 98 days, whereas those taking 1.7 megarads were still satisfactory after 191 days. Studies indicated that 100,000 rads would be suitable for mold control.

Pasteurized raw peaches inoculated with *Phizopus nigricans* were free from infection 10 days after treatment at 230,000 rads and 6 days after treatment at 140,000 rads. Nonrayed controls rotted completely in 5 days. Doses above 280,000 rads brought textural and skin-color abnormalities.

Dosing of plums at somewhat less than 372,000 rads did not alter their acceptability characteristics.

Pineapple: Blanched and unblanched pineapple chunks exposed to 740,000 and 930,000 rads suffered severe flavor changes. Chunks given 46,000 and 93,000 rads showed a slight reduction of bacteria organisms. Objectionable off-flavor developed in this fruit when the dosage reached 93,000 rads.

Rhubarb: Stems of rhubarb given



New Unit Will Ray-Pasteurize 6,000 Food Packets Hourly

Global scale of food-irradiation research is evidenced by word that the Danish Atomic Energy Commission has ordered a powerful new 10-mev. linear electron accelerator (depicted here in an artist's conception). It will be installed late this year in Copenhagen's Niels Bohr Laboratory.

Being built by Varian Associates (Palo Alto, Calif.), this unit will be capable of pasteurizing 6,000 lb./hr. of prepackaged foods, using ½-megarad doses.

Seen in foreground are control panel and cabineted pulse modulator. Behind cutaway guard wall is irradiation unit. Note ray gun (right end) directing electron beams at food packages passing below on moving belt.

1.86 megarads became limp and showed a pronounced loss of the sharp acid flavor. After 4½ months' storage at 40F., rhubarb sauce irradiated at 930,000 rads in film pouches (polyethylene-coated Mylar), had an acceptable flavor. Color of the sauce progressively degraded as doses were increased from 142,000 to 930,000 rads.

Checks On the Vegetables

Asparagus: A slight preference was indicated for non-irradiated samples of asparagus as compared with those given 186,000, 465,000, and 930,000 rads. A loss of characteristic bouquet was noted at 930,000 rads, and the product was softened and bleached. At lower doses it was termed "flat".

Refrigerated shelf-life of hermetically sealed blanched asparagus was more than tripled by irradiation to 0.37 magarad. However, it has been observed that counts of aerobic and anaerobic bacteria continue to increase during storage.

Snap beans: Storage studies indicate that 93,000 rads yield a better bean than do doses of either 460,000 or 930,000. Blanched samples given up to 930,000 changed from green to dull olive, lost their characteristic flavor, and broke down physically within 5 weeks at 40F.

Lima beans: Refrigerated shelf-life of hermetically sealed blanched lima bean samples irradiated to 450,000 and 690,000 rads has been extended approximately four times. These storage tests are continuing.

Beets: This vegetable was cooked, peeled, sliced, and packaged in the poly-Mylar envelopes, then given 930,000 rads and stored with non-rayed samples at 40F. After 1 month, treated samples still had a fresh flavor. However, they had lost their bright pigmentation and turned a dark maroon.

Broccoli: Blanched for 2 min. and irradiated at 695,000 rads, broccoli was still considered good after 27 days. Non-rayed samples similarly blanched began to break down after 13 days of refrigerated storage. Rayed samples were described as having a bright color and a slightly flat taste, but no off-flavor, signs of mold, or other deterioration.

Brussels sprouts. This vegetable, when blanched in boiling water and subsequently irradiated at 698,000 and 930,000 rads, developed a strong acrid taste after 2 weeks in refrigerated storage.

Cabbage: Heads given 230,000 rads remained acceptable. But at 930,000 rads severe loss of texture was observed. Odor and flavor were unchanged up to 1.86 megarads. However, heads taking up to 2.79 megarads were organoleptically undesirable.

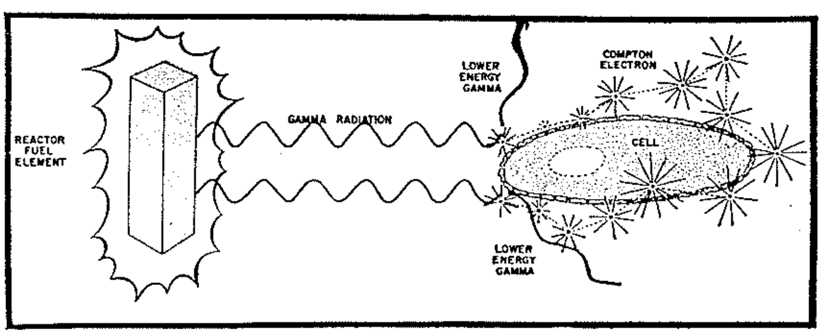
Relative to shredded cabbage, no color, texture, or flavor changes were noted in samples taking 47,000 and 140,000 rads. After irradiation, the packaged product (perforated cellophane or polyethylene bags) had prolonged refrigerated shelf-life—up to 25 days, as compared with 6-7 days for unrayed controls.

Carrots: Undesirable sensory characteristics were produced by 465,000 rads, but were removed by cooking. This dosage, however, was generally insufficient to protect against microbial spoilage in 70F. storage.

Cauliflower: The threshold dose, short of producing off-flavors in blanched cauliflower, was found to be considerably below 100,000 rads. As this is below levels necessary to control microorganisms, no further work was performed.

Celery: Here, flavor and texture were lost under doses to 230,000 rads. Some of flavor returned after storage at 36-40F. for 1 week.

Corn: Blanched corn proved sensitive to irradiation, with off-flavors at doses of less than 1 megarad.



MECHANISM OF IONIZING RADIATION: Created by treatment (gamma rays depicted) is an environment incompatible with the cell's continued function. Relatively few rays act directly on cell itself.

Cucumbers: Loss of texture and offensive odors when given more than 930,000 rads.

Endive: No flavor change noted when treated with 46,000 rads, although a non-rayed control sample was preferred. Rayed endive remained satisfactory after 19 days, whereas the control had spoiled.

Lettuce: No marked irradiation odor or flavor were noted at 930,000 rads. But poor quality was observed due to loss of crispness and natural flavor. It's interesting that a slight, but statistically significant, firming of lettuce appeared at 43,000 and 340,000 rads, with softening not starting until about 600,000 rads.

Peas: At 744,000 rads there was a softening effect on blanched green peas. This was equivalent to boiling peas an additional 4 min. after blanching. Using a blanch with sodium ascorbate, peas receiving 1.4 magarads were acceptable after 45 days at 38F.

Spinach: Blanched spinach given up to 930,000 rads remained good after 12 days' storage at 40F., but was in poor condition after 18 days. Unblanched spinach was adversely affected even at 93,000 rads.

Squash: Although no particular color or textural changes were noted at 465,000 rads, the organoleptic threshold dosage was reported to lie between 140,000 and 195,000 rads.

Tomatoes: With firm, ripe tomatoes, inoculated with *Alternaria tenuis*, 279,000 rads delayed rot for 10 to 11 days at 70 to 75F. In comparison non-rayed controls showed initial rot after 3 days.

Under 279,000 rads, rotting was proportionately faster. At 46,000 rads there was no appreciable difference between treated tomatoes and controls. At 465,000 rads or above, no rot was evident over 16 days.

Injuries such as softening of tissue and bleaching of skin were noted at progressively higher dosages (over 465,000 rads). Some studies indicate that irradiation of green or pink tomatoes produces erratic ripening behavior.

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